Tendon-Actuated Lightweight In-Space MANipulator (TALISMAN)

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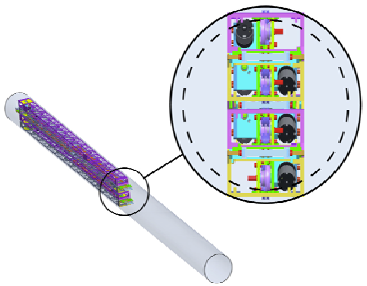
Background

NASA mission and exploration architecture studies show that devices for maneuvering and precisely placing payloads are critical for efficient space operations involving reusable assets or in-space assembly and construction. New missions and applications such as: asteroid retrieval and redirection, asteroid mining, satellite servicing, small payload delivery to space stations and large space observatory assembly can all benefit from having long reach manipulators.

A New Approach

The robotic architecture of state-of-the-art space manipulators, represented by the Shuttle Remote Manipulator System (SRMS), inherently limits their capabilities to extend reach, reduce mass, apply force and package efficiently. TALISMAN uses a new and innovative robotic architecture that incorporates a combination of lightweight truss links, a novel hinge joint, tendon-articulation and passive tension stiffening to achieve revolutionary performance. A TALISMAN with performance similar to the SRMS has 1/10th of the mass and packages in 1/7th of the volume when compared to the SRMS. The TALISMAN architecture allows its reach to be scaled over a large range; from 10 to over 300 meters. In addition, the dexterity can be easily adjusted without significantly impacting manipulator mass because the joints are very lightweight.

TALISMAN and SRMS Performance Comparison



Design Parameter	SRMS	TALISMAN
Total manipulator reach	15.3 m (50 ft)	15.3 m (50 ft)
Manipulator Mass	410 kg (904 lbf)	36.1 kg (79.6 lbf)
Packaged volume	1.74 m^3 (61.4 ft^3)	0.23 m^3 (8 ft^3)
Degrees of Freedom (DOF)	6 total: 2 at base, 1 elbow, 3 wrist	5 total: base rotation, 4 hinges

A first-generation full-scale TALISMAN prototype, designed for satellite servicing, has been fabricated and is currently undergoing operational testing. This application is focusing on achieving: high dexterity, a large reach envelope, applying and reacting large tip forces, being able to deploy and restow multiple times, while packaging compactly for launch.

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Key Features

- Uses tendon actuation, semi or fully antagonistic, with major components being the links, spreaders, and lightweight cables, motors, gearboxes
- Increased joint stiffness due to tendon architecture
- Lightweight joints enable the number of joints to be optimized to achieve desired packaging, efficiency, range-of-motion, dexterity, etc.
- Potential to increase stiffness using passive tension elements (very lightweight)
- Versatility; many different cable/motor/control options can be implemented
- Modularity; links and joints are easy to scale for different applications, can combine links and joints to achieve operational needs
- Novel hinge joint allows full 360-degree rotation between adjacent links, improving dexterity and range of motion
- Uses lightweight truss structures for links.

TALISMAN operational testing at NASA Langley Research Center Flat Floor, June 2014

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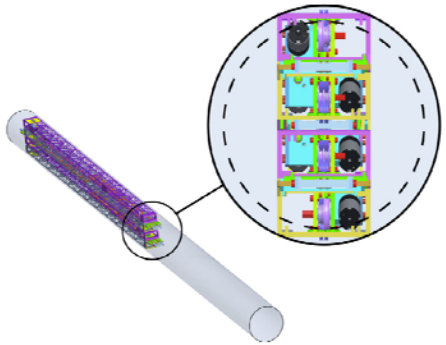

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